(12) UK Patent Application (19) GB (11) 2 138 562 A

(43) Application published 24 Oct 1984

(21) Application No 8409806

(22) Date of filing 16 Apr 1984

(30) Priority data

(31) 8310611 (32) 19 Apr 1983 (33) GB

(51) INT CL[3]
G01B 9/00

(52) Domestic classification
G1A A2 D11 EF G10 G1 G2 G5 G7 G8 R7 S11 T15 T25 T3 T8
U1S 1660 2055 2145 G1A

(56) Documents cited
GB A 2079935 GB A 2021260
GB A 2069690 GB 0800559

(58) Field of search
G1A

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(54) Measurement of profiles of irregular objects

(57) The profile of an irregular shaped object is measured in an in-line extrusion process. This entails passing the object through an optical measuring gate which is rotated around the material, as the material intercepts the path of the beam across the gate. The intercepted beam is then monitored by suitable means to determine the shape of the profile. This assists *inter alia* in maintaining control of the size of the material and conformity to the required specification. The measuring gate includes a light source which directs a beam towards a photocell, the source and photocell being mounted on rings which are reciprocated through angles of 180° around the object as it is extruded. The thickness of a coating on the object may be determined by using respective apparatuses to determine the object's diameter before and after coating. The object may be an electrical cable.

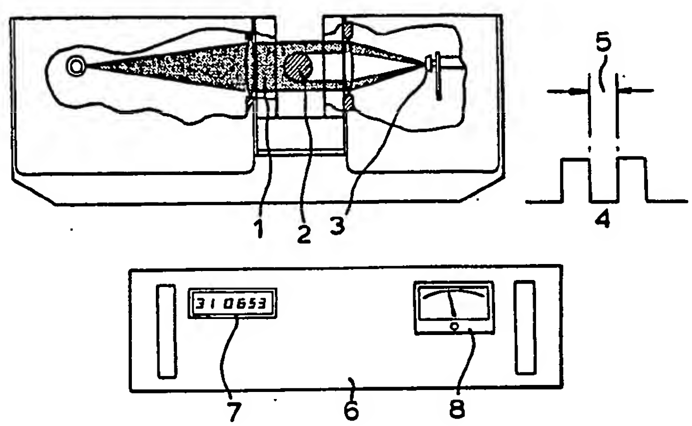

FIG.1.

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The drawings o[illegible] rmal copy.

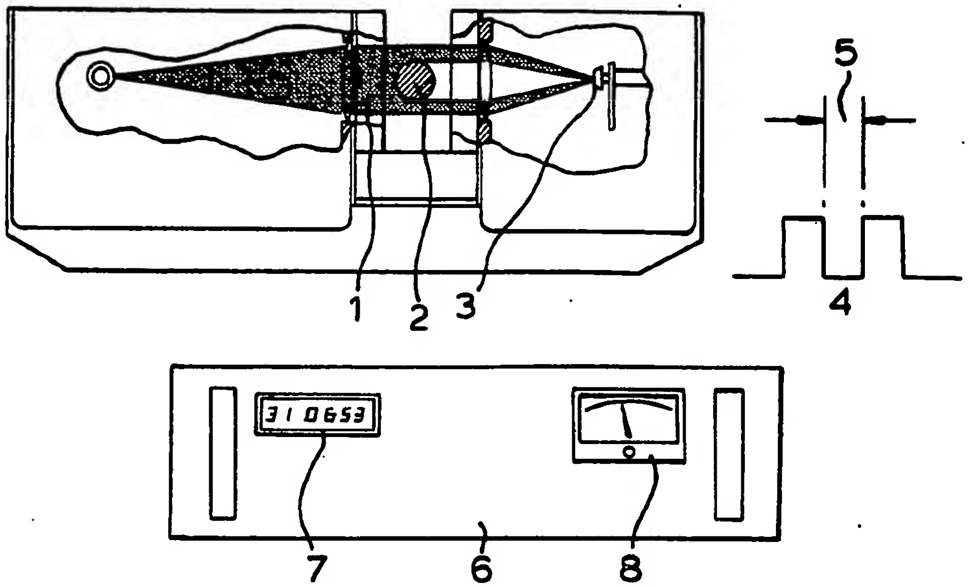

FIG.1.

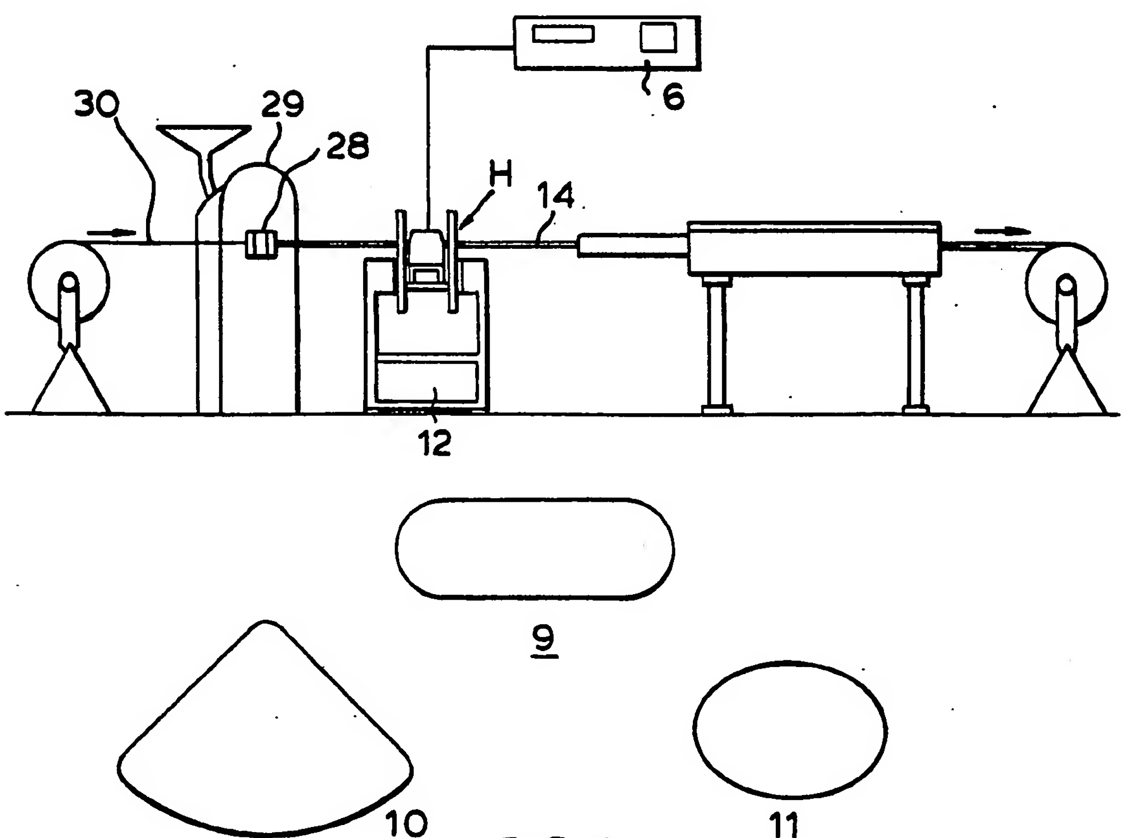

FIG. 2.

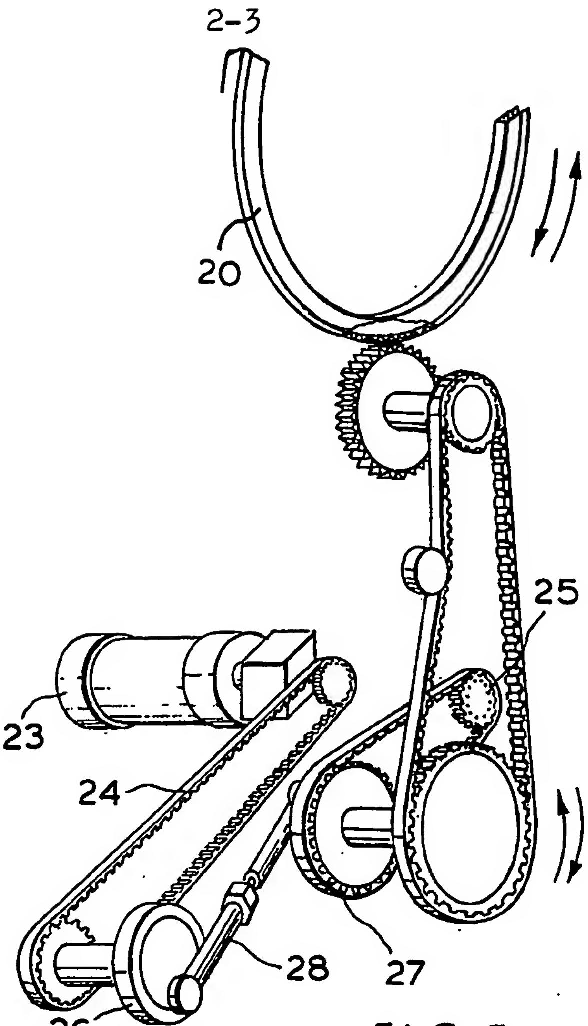

FIG. 3.

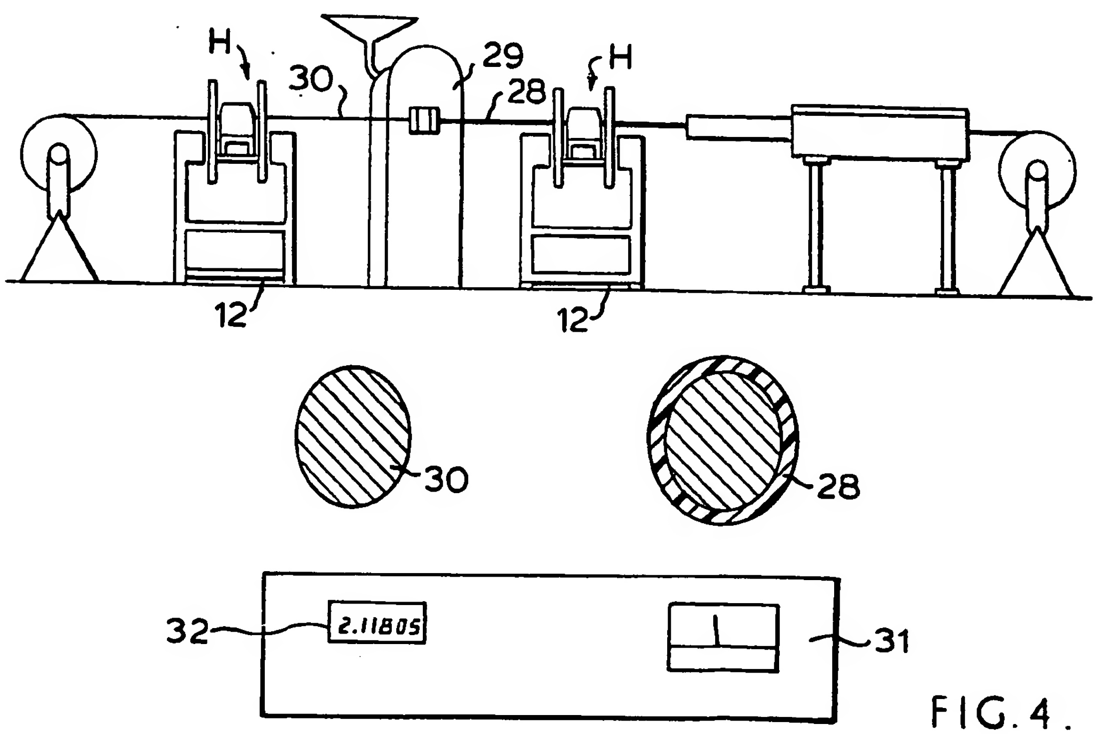

FIG. 4.

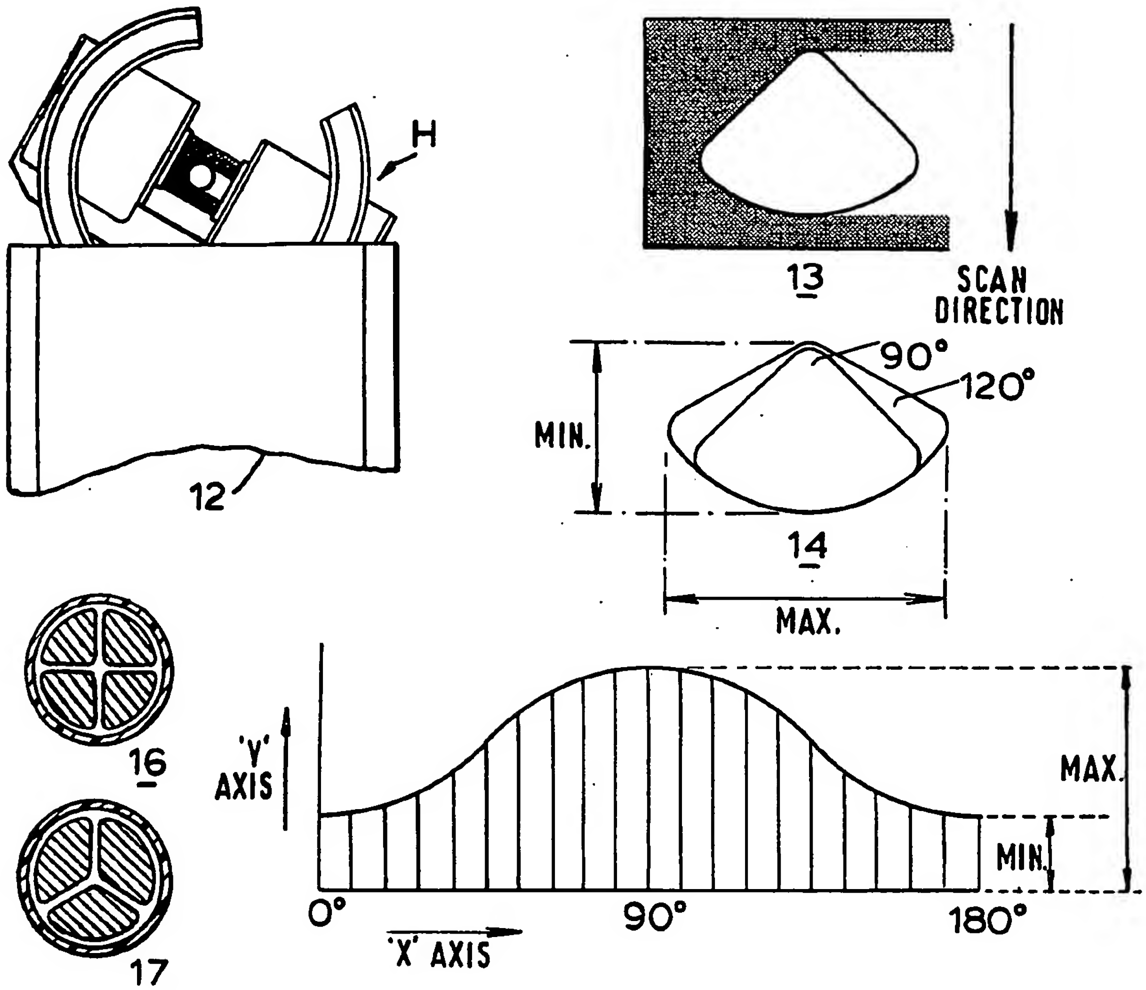
H
12
13
SCAN
DIRECTION
90°
120°
MIN.
14
MAX.
16
17
'Y'
AXIS
MAX.
MIN.
0°
90°
180°
'X' AXIS

FIG.5.

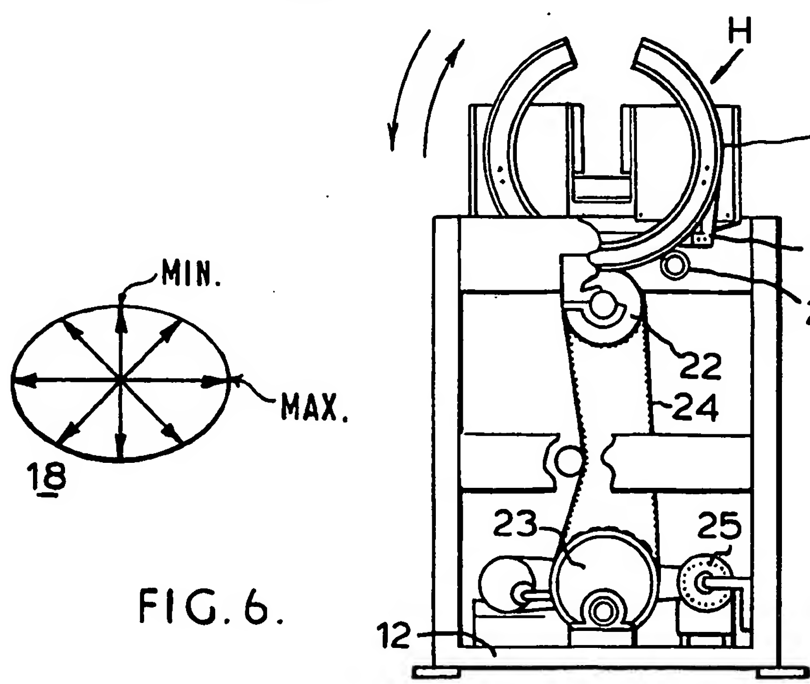
MIN.
MAX.
18
H
20
19
21
22
24
23
25
12

FIG.6.

SPECIFICATION
Measurement of profiles of irregular objects

The present invention relates to a method and apparatus for the measurement of irregular shaped materials of elongated form during an extrusion or other production process.

During an extrusion process it is desirable to monitor the profile of the extruded material. The reason for this is to control the profile of the material thus effecting, not only cost savings, but also adherence to the required specification.

It is common practice that when a cable of circular shape is extruded, a diameter profile instrument may be used to measure the overall diameter of the cable. This method works quite satisfactorily and, as it assumes that the product is essentially round, a reasonably accurate measurement of its size can be effected.

Measurement should preferably be by optical means so that no contact is made with the material. This has the advantage of providing precise measurement without problems of wear which is a feature of the contact type methods. Additional advantages, of course, are provided by non-contact methods, in a situation where the material to be measured is in a hot or plastic state, and here it would be quite impossible to effect a contact type measurement.

The purpose of the present invention is to supplement the shortcomings of the prior art, by providing a non-contact method and apparatus for determining the profile of elongate material of sectorised and oval cross-section.

According to one aspect of the invention there is provided a method of measuring the profile of elongate material produced in an extrusion process comprising passing the elongate material through an optical measuring gate having means for transmitting and receiving a beam of light, such that the material intercepts the path of the beam and monitoring the intercepted beam to determine the profile of the material characterised in that the transmitting and receiving means is moved round the material to determine the overall profile thereof.

With this method accurate profile measurements of irregular shaped material becomes possible, and the results displayed graphically from which the cross-sectional area of the material, on a continuous basis for example in an in-line extrusion process, may be obtained.

Other features and advantages of the invention will become apparent from the subsequent disclosures to this end.

The invention will now be described by way of example with reference to the accompanying drawings wherein:

Figure 1 illustrates apparatus for measuring the profile of an extruded cable according to the prior art;

Figure 2 is a side view of an extrusion line process incorporating apparatus for measuring the profile of an extruded cable according to the invention;

Figure 3 is a detailed illustration of the drive of the apparatus for measuring the profile of an extruded cable;

Figure 4 is a side view of an extrusion line process incorporating apparatus for measuring the profile of an extruded cable before and after being coated;

Figure 5 is a graphic representation of the results obtained with the apparatus of the invention when used to measure a profile of sectored cross-section; and

Figure 6 is a cross-sectional view through apparatus according to the invention.

Referring now to Figure 1 which shows an optical gauging instrument similar to the unit described in British Patent Application 8214294, which has the capability of scanning a fine beam of light across an optical gate 1. The beam is intercepted by the profile 2 to be measured, thus producing at the receiving end on a photocell 3, a square wave output of electrical current 4 in which a central portion 5 represents the diameter of the profile. The square wave 4 can be fed through electrical circuitry to an indicator unit 6 which will display the actual diameter of the material 7 directly in units of millimetres or inches.

The indicator 6 is preferably equipped with a deviation meter 8 which displays the deviation of diameter from a preset value as the product is extruded in a typical extrusion line.

In order to achieve measurement of irregular section materials, a method has been devised using a rotatable optical measuring head H mounted on a stand 12, see Figure 2, 4, 5 and 6, the stand 12 having the capability of rotating, rocking or oscillating the optical measuring head H about the axis of the irregularly shaped material 13, see Figure 5, through some 180° rotation.

This method ensures that, as the rotating head H revolves around the axis of the irregular material, a series of measurements are performed around the cross-sectional area of the product, and as the rotating head H goes through one complete cycle (which is 180° of rotation) a series of profile measurements are made which represent the ordinates of the profile of the material.

Considering an irregular material 14 Figure 5, this would appear to have a maximum and minimum dimension due to its construction. If this material is introduced through the rotating head H at the end of one cycle, a series of measurements will be performed, which may be represented in graphical form.

A representative graph 15 is shown in Figure 5, the Y axis denoting actual profile measurement in millimetres, and the X axis the degree of rotation at which these measurements were made. Each vertical ordinate in the Y axis, represents a profile measurement at a certain angle of rotation of the measuring head H.

The optical head H utilised in this application, should preferably be of a high scanning rate in the order of 200—400 scans per second, and have a time cycle of some 6—10 seconds. This will

enable the system to perform a large number of ordinate measurements through one complete cycle and therefore a very accurate profile measurement can be obtained.

It is clear, from graph 15, Figure 5, that a measurement of the maximum dimension can be obtained of the material and also a minimum dimension can be obtained as well and, assuming that the material is of a sector shape 14, that is to say that it has either a 90° or a 120° root angle, a very accurate cross-sectional area calculation can be performed.

The irregular shaped materials 14 would probably be sectorised conductors either for a 4 phase type of cable 16 or a 3 phase type of cable 17 as shown in Figure 5. A further application of this method of measurement would be in the case of an oval or near oval type of profile 18, Figure 6, in which the maximum and minimum axis can be measured and, indeed, a series of other ordinates would provide an accurate measurement of the profile of the material.

The apparatus for performing these measurements as shown in Figure 6, comprises a stand 12 mounting an optical measuring head on a platform 19, which in turn is mounted on two circular rings 20 which are held in position by a series of rollers 21. The rings 20 can be driven by a rack and pinion mechanism 22 coupled to an electric motor 23 via a timing belt system 24.

A typical encoder 23 is mounted on a part of the stand 12 and has the capability of outputting signals of the exact position of the rotating rings 20. This is an important feature of the system as the encoder signals can locate the position at which a particular measurement of profile is made. The motor 23 drives the rings 20 through 180° in one direction, clockwise, and has the capability to reverse and drive the rings through 180° in an anticlockwise direction.

An important feature of this disclosure is the electrical drive which oscillates the measuring apparatus around the product. Referring to Figure 3, an electric motor, preferably an AC type 23, drives, through a timing belt 24, and idling pulley 26, which in turn is coupled to a larger pulley 27 through a crank 28. The size of the larger pulley is such that the crank operates in an oscillatory motion and, while the smaller pulley 24 is continuously rotating, the larger pulley 27 is oscillating through a certain angle.

This system has advantages in that no motor reversal is necessary to produce an oscillatory movement which is required to drive the rings of the optical gauge head by careful selection of driving pulleys, the rate of oscillation can be adjusted and by alternative selection of larger pulleys the angle of oscillation through which the rings oscillate can also be adjusted.

Other features of this apparatus include a device for stopping the rotating rings and head in any desired position. Further capabilities include driving the rings at different speeds so that the cycle can be completed at various time intervals required by the particular application. At the beginning and end of each cycle an output signal is available to initiate or terminate the calculations or measurements that the optical system has performed.

In some cases it may be desirable to rotate the rings through an angle less than 180° and these facilities are also available.

The system as described here has applications in a straightforward extrusion line as shown in Figure 2, whereby plastic coating material 28 is extruded continuously from the extruder 29 onto the travelling material 30 which has an irregular profile. The stand 12 is utilised in measuring the maximum and minimum dimensions of the sectorised product 14. This application can be extended into a control application in which a feed back signal can be derived from the optical measuring system, indicated in Figure 1 in relation to the prior art, to control the amount of plastic material 28 being extruded on the product 14 so as to effect closed loop control and specification maintenance.

The third application involves a wall thickness control system (Figure 4) in which two rotating stands with optical measuring systems are utilised, one before the extruder 29 measuring the core material 30 and the second after the extruder measuring the plastic coating 28 on the conductor 30. In this application a mean area is calculated for the core material as well as for the final product and a computer unit 31 is utilised to give the mean wall thickness 32 of the plastic coating on the extruded product.

Embodiments of the invention are summarised as follows:

Summary 1

A method by which an irregularly shaped material, such as sectorised conductor, can be measured during production by a non-contact method.

Summary 2

A method by which a sectorised or oval type conductor can be measured and the maximum and minimum dimensions of this conductor be determined for indication or control purposes.

Summary 3

A method by which two rotating or oscillating optical measuring systems can be used in an extrusion process which extrudes a plastic jacket on to the material and in which the two optical measuring systems are rotated or oscillated around the material and thus measure the average wall thickness of the extruded material.

Summary 4

A method by which two rotating or oscillating optical measuring systems can be used in an extrusion process which extrudes a plastic jacket on to the material and in which the two optical measuring systems are rotated or oscillated around the material and thus measure the average wall thickness of the extruded material.

Summary 5

An apparatus for rotating or oscillating an optical measuring system around irregularly shaped material either stationary or moving which has the capability of rotating through a full or part circle thus providing ordinate measurements of the material profile.

Summary 6

An apparatus, as described in Summary 5, which embodies an optical encoder which can output signals of the position of the rotation of the measuring system.

Summary 7

An apparatus, as described in Summary 6, which can rotate or oscillate an optical measuring system through a full or part of a circle around a stationary or moving product with the capability of outputting a signal at the beginning or end of each rotation.

Summary 8

An apparatus, as described in Summary 7, which rotates backwards and forwards through a part or full part of a circle and mounts and carries an optical measuring system.

Summary 9

An apparatus, as described in Summary 8, which has the capability of rotating at a certain speed, backwards and forwards, through a part or full circle, and has the capability of being stopped at any point through each rotation.

Summary 10

An apparatus which is capable of oscillating backwards and forwards about a product through a predetermined angle which is driven from a continuous non-reversing motor through a pulley and crank mechanism as described in the body of this disclosure.

CLAIMS

1. A method of measuring the profile of elongate material produced in an extrusion process comprising passing the elongate material through an optical measuring gate having means for transmitting and receiving a beam of light, such that the material intercepts the path of the beam, and monitoring the intercepted beam to determine the profile of the material characterised in that the transmitting and receiving means is moved round the material to determine the overall profile thereof.

2. A method as claimed in Claim 1 characterised in that the transmitting and receiving means is rotated through an angle of 180° in one direction and then through the same angle in the opposite direction, on a continuous basis.

3. A method as claimed in Claim 2 characterised in that a profile measurement at each angle of rotation of said transmitting and receiving means is represented as the ordinate on a graph.

4. A method as claimed in any preceding claim characterised in that the material is scanned by the beam in the order of 200—400 scans per second, during rotation of said transmitting and receiving means.

5. A method as claimed in Claim 4 characterised in that the transmitting and receiving means is rotated at 6—10 cps.

6. A method as claimed in Claim 1 characterised in that the transmitting and receiving means is moved around the material before and after extrusion to determine profile characteristics of the core and plastics coated material respectively, such that the thickness of the plastics coat may be determined.

7. Apparatus for measuring the profile of elongate material comprising means for transmitting and receiving a beam of optical radiation, characterised in the provision of means for rotating said transmitting and receiving means around the elongate material as the material intercepts the beam, thereby to determine the overall profile of said material.

8. Apparatus as claimed in Claim 7 characterised in that said transmitting and receiving means includes a transmitter for emitting a beam of light and a photocell for receiving the beam, said transmitter and photocell receiver being mounted respectively on a rotatable ring, and means coupled to the rings for effecting rotational movement through predetermined angular distances.

9. Apparatus as claimed in Claim 8 characterised in that said rotatable means includes a crank mounted between two rotatable pulleys, one of said pulleys being of such a size in relation to the other that rotation thereof causes said one pulley to oscillate, and drive means between said one pulley and a respective said ring to effect oscillatory movement thereof through 180° in one direction and 180° in the opposite direction, around said material.

10. A method of measuring the profile of elongate material substantially as hereinbefore described with reference to and as illustrated in Figures 2 to 6 of the accompanying drawings.

11. Apparatus for measuring the profile of elongate material substantially as hereinbefore described with reference to and as illustrated in Figures 2 to 6 of the accompanying drawings.

Printed in the United Kingdom for Her Majesty's Stationery Office, Demand No. 8818935, 10/1984. Contractor's Code No. 6378.
Published by the Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.